Fisheries Research 172 (2015) 157–167

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Effect of underwater lighting on observations of density and behavior of rockfish during camera surveys

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ARTICLE INFO

Article history:
Received 20 January 2015
Received in revised form 12 June 2015
Accepted 10 July 2015

Keywords:
Underwater stereo imagery
Underwater lighting
Sebastes
Visual surveys
Habitat studies
Puget sound

ABSTRACT

Unbiased visual observations of fish are increasingly important for a number of management issues, such as non-extractive abundance estimates and fish-habitat associations. We tested the effect of three types of underwater lighting on observable rockfish density and behavior using an underwater stereo camera. Higher densities of small rockfish were observed on deployments conducted with strobed red lights (where rockfish are less spectrally sensitive) than with either strobed white light or constant white light. The difference between strobed red lights and constant white light was statistically significant. For three larger species of rockfish there was no significant effect of lighting on fish density. Rockfish behavioral responses measured by the range-dependent height off the seafloor were also lowest for the red strobe light deployments, although not significantly different than for white strobe light. Rockfish height above the seafloor decreased as the drop camera approached in all treatments for both small and large rockfish. Small rockfish exhibited stronger responses to light treatments both in terms of density and observed height off the seafloor, while large rockfish were less sensitive to any of the light treatments. The implications of this study are that white lights decrease the observed density of small rockfish during underwater surveys, and the degree to which lighting regimes overlap the spectral sensitivities of target fishes can determine fish reactions.

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1. Introduction

Visual surveys for marine fishes have become more prevalent in recent years with the development and accessibility of new technologies (such as stereo image processing), the desire by management agencies to conduct non-extractive studies (for rare or endangered species), and the need to survey fishes in areas where traditional sampling gears are not appropriate (such as untrawlable rocky areas). Underwater imagery has been commonly used to assess fish associations with their habitat (Hixon et al., 1991; Stein et al., 1992; Auster et al., 2003; Love et al., 2009) and less commonly used to estimate fish abundance using non-lethal methods (O'Connell and Carlile 1993; Yoklavich et al., 2007). More recently, underwater imagery has been used in combination with other methods such as acoustics to estimate population abundance of difficult to assess species (Demer et al., 2009; Ressler et al., 2009; Rooper et al., 2010; Jones et al., 2012). To a large degree, all of these applications of underwater visual observations depend on unbiased estimates of fish species composition, fish abundance and fish sizes in different habitats, yet the effect of the observation platform on the observations are rarely measured (see review by Stoner et al., 2008).

Underwater platforms for visually assessing fish-habitat associations and fish abundance have included basic systems such as drop cameras (Rooper et al., 2010; Jones et al., 2012), remotely operated vehicles (O'Connell and Carlile, 1994; Stone, 2006; Stierhoff et al., 2013) and manned submersible vehicles (O'Connell and Carlile, 1993; Yoklavich et al., 2007). Stimuli associated with underwater platforms can include artificial lighting, underwater platform noise, water displacement from platform motion, platform speed, chemical or electromechanical stimuli (Stoner et al., 2008), and stimuli from the underwater plotform support vessel (De Robertis and Handegard, 2013). In the few studies that have been conducted, the effect of an underwater platform on the behavior of fishes is often found to vary with species (Trenkel et al., 2004; Lauth et al., 2004; Laidig et al., 2013). Rockfish (*Sebastes* spp.) are a taxonomic group that is often the subject of visual surveys due to their predisposition to occur near the seafloor in rocky or rough areas where other types of sampling (such as trawls or set nets) are ineffective. Field studies of rockfish have observed differential reactions to underwater

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http://dx.doi.org/10.1016/j.fishres.2015.07.012
0165-7836/Published by Elsevier B.V.

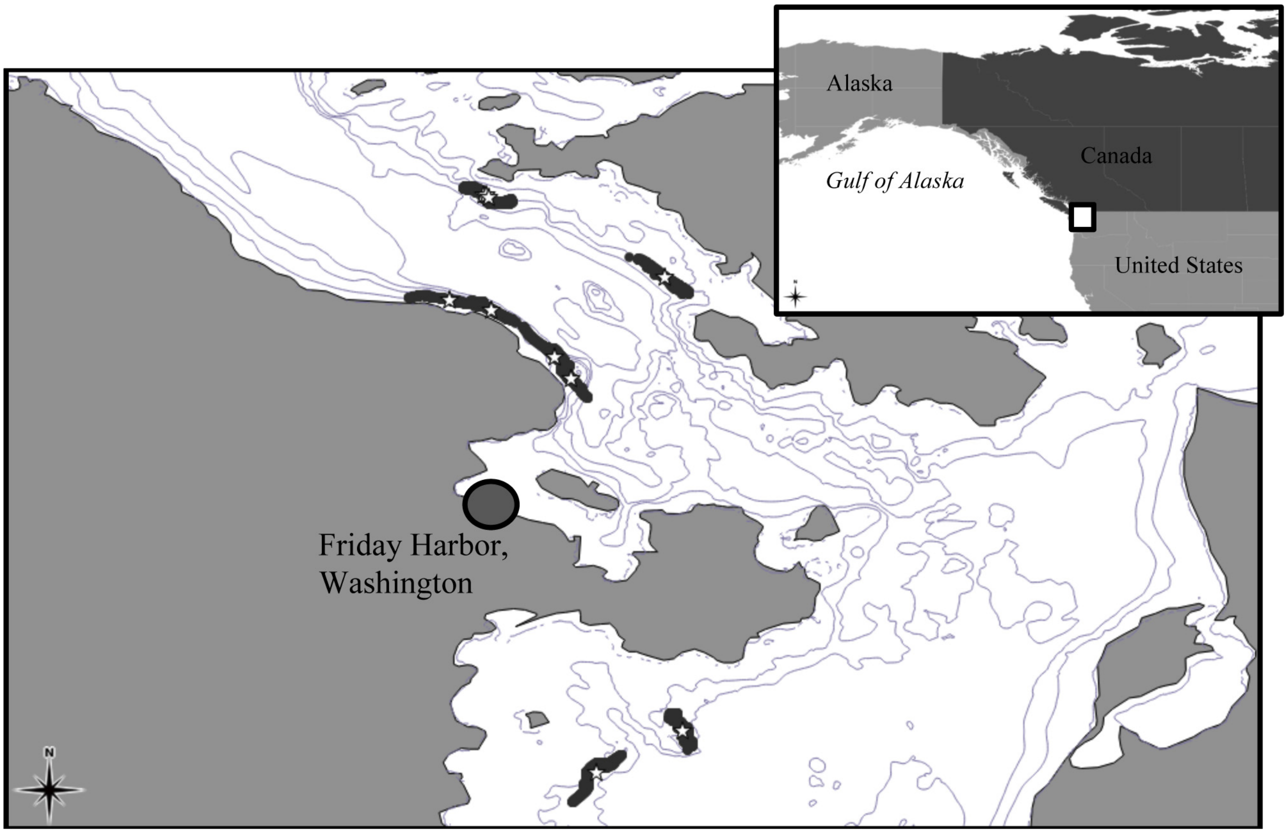

Fig. 1. Map of study area near Friday Harbor, Washington, showing the transects ($n = 11$) where three deployments were conducted (one for each light treatment). Stars indicate the center point of each transect, the grey areas show the full extent of the transects. The northernmost grey area contained 4 closely spaced transects. Four transects were spaced end to end in the grouping just north of Friday Harbor.

platforms, including diving to the seafloor, changing the speed or direction of swimming, following the platform, or limited reaction to the platform (Pearcy et al., 1989; Hixon et al., 1991; Krieger and Ito, 1999; Lauth et al., 2004; Lorance and Trenkel, 2006; Laidig et al., 2013), indicating there could be potential biases in abundance estimates associated with fish reactions to the observation platforms during visual surveys.

The artificial lighting associated with underwater visual platforms is often considered to be the predominant source of disturbance and potential bias for fishes during visual surveys (Stoner et al., 2008). However, the effects of different lighting regimes on fish avoidance behavior have only rarely been studied. A single published laboratory study by Ryer et al. (2009) examined the effects of the approach of artificial lighting on seven marine fish species, and found that reactions to the light varied among them. Few field studies have examined the effect of lighting on the abundance of observed fishes. Widder et al. (2005) found that the number of sablefish (*Anoplopoma fimbria*) observed was higher when illumination was provided with red as opposed to white lights, and Trenkel et al. (2004) found an increase in white light intensity resulted in a decrease of observed fishes. In general, fish vision is sensitive to light wavelengths in the range of blue (400 nm) to far-red (700 nm) (Bowmaker, 1990; Douglas and Hawryshyn, 1990). A study on black rockfish (*Sebastes melanops*) indicates they are sensitive to light in the range from 380 nm to 620 nm (Brill et al., 2008) In a laboratory study, it was found that rockfish reaction to white light from an incandescent source was generally moderate, but varied with species (Ryer et al., 2009). Based on the review of Stoner et al. (2008) and research of Ryer et al. (2009), we expected that the rockfish exposed to light that fell within the wavelengths of high sensitivity would have an avoidance reaction to the camera, either by moving away from the camera prior to their being observed (causing a decrease in observed density) or by moving toward the refuge of seafloor (causing an observed decrease in height above the seafloor).

Thus, the objectives of this study were to determine the effects of three lighting treatments on the abundance of rockfish observed with a drop camera in terms of rockfish density and maximum number observed. Where species of rockfish could be determined, differences in abundance were compared among species. A secondary objective was to examine rockfish avoidance (measured by changes in density) with distance from the drop camera, and rockfish behavior (measured by the height of rockfish off the seafloor) under the three lighting treatments. Where possible, these comparisons were also made among species.

2. Material and methods

This study was conducted from November 18 to 22, 2013 in the San Juan Islands near Friday Harbor, Washington (Fig. 1). The University of Washington research vessel Centennial was used for all operations. Maps of seafloor substrates have been completed for much of the San Juan Archipelago (Greene et al., 2007) that show areas of potential hard rocky substrate. Surveys with remotely operated vehicles have also been conducted in the area, which indicated potential areas of high rockfish concentration (R. Pacunski, Washington Department of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501, U.S.A., personal communication). Based on initial explorations using the ships echosounder, drop camera system, previous rockfish sightings and the seafloor substrate maps, 11 transects were chosen (Fig. 1). The 11 transects ranged in depth from 36 m to 69 m (mean = 54 m, SE = 1.6).

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